

Ko-WADiS – Evaluating the Development of Scientific Inquiry Competencies in Academic Science Teacher Education

Straube, P., Stiller, J., Mathesius, S., Hartmann, S., Nordmeier, V.,
Tiemann, R., Upmeier zu Belzen, A., Krüger, D.

Relevance and aims

According to various researchers, there is a need for empirical, competence-based studies in academic science teacher education (Reinhold, 2004; Schecker & Parchmann, 2006; von Aufschnaiter & Blömeke, 2010; Zlatkin-Troitschanskaia & Kuhn, 2010). Such studies will be necessary to evaluate the success of university courses, and to develop academic education (Wissenschaftsrat, 2008). Thereby, modeling and assessing competencies serve as a basis for policy control.

Project Ko-WADiS sets out to establish a reliable instrument to evaluate the development of competencies in the field of scientific inquiry during the phase of academic science teacher education. It is conducted in collaboration of the departments of biology education and physics education at Freie Universität Berlin and the departments of biology education and chemistry education at Humboldt-Universität zu Berlin.

Research questions

The main research questions of project Ko-WADiS are: What empirical evidence can be found to support a theoretically predicted model of competencies? How do competencies in the field of scientific inquiry develop during the phase of academic science teacher education?

Theoretical background

Competencies in the field of scientific inquiry are often described as science syntactic knowledge (Abell, 2007) and thus constitute a component of teachers' professional knowledge (Baumert & Kunter, 2006). Scientific inquiry competencies are assumed to be a fundamental part of scientific literacy (American Association for the Advancement of Science [AAAS], 1993; Bybee, 2002; National Research Council [NRC], 2012) and play a key role in the education of (future) science teachers (Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland, 2010). "Scientific inquiry refers to characteristics of the scientific enterprise and processes through which scientific knowledge is acquired" (Schwartz, Lederman, & Crawford, 2004, p. 611). According to Mayer (2007), the way of acquiring scientific knowledge is a complex problem solving process. Based on assumptions made by Mayer (2007) and Upmeier zu Belzen and Krüger (2010), the underlying theoretical model of the competence structure in the field of scientific inquiry consists of two domains: conducting investigations and using models. These domains can be further divided into sub-dimensions (fig 1).

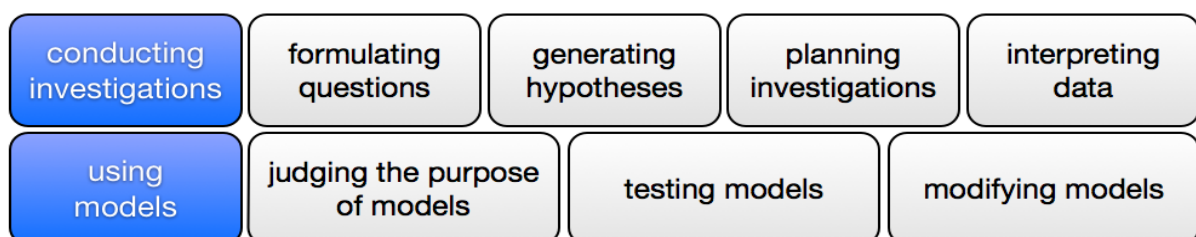


Figure 1. Domains (blue) and sub-dimensions (grey) of scientific inquiry.

Research design

To assess these competencies, a paper-pencil test with 146 multiple-choice items was developed. A pilot study (N ~ 650) is scheduled for summer 2013. The instrument will be used in a longitudinal survey assigned to different text booklets (multi-matrix design) in order to answer the central research questions. The longitudinal survey will start at the end of summer semester 2013. Every student will be tested twice during the bachelor stage and twice during the master stage of academic teacher education. Data will be analyzed using methods of Item-Response-Theory.

The project is funded by the Federal Ministry of Education and Research as part of the program Modeling and Measuring Competencies (KoKoHs). The first stage of the project ends in April 2015.

Project data

Project management	Prof. Dr. Dirk Krüger, FU Berlin Prof. Dr. Annette Upmeyer zu Belzen, HU Berlin
Associated cooperation partners	Prof. Dr. Martin Hopf, Universität Wien Dr. Suzanne Kapelari, Universität Innsbruck Prof. Dr. Hans Anand Pant, HU Berlin Prof. Dr. Günther Pass, Universität Wien Dr. Franz Radits, Universität Wien Prof. Dr. Philipp Schmiemann, Universität Duisburg-Essen Prof. Dr. Felicitas Thiel, FU Berlin
Cooperation partners	Prof. Dr. Volkhard Nordmeier, FU Berlin Prof. Dr. Rüdiger Tiemann, HU Berlin
Scientific staff	Stefan Hartmann, HU Berlin Sabrina Mathesius, FU Berlin Jurik Stiller, HU Berlin Philipp Straube, FU Berlin
Contact person	philipp.straube@fu-berlin.de jurik.stiller@hu-berlin.de sabrina.mathesius@fu-berlin.de stefan.hartmann@hu-berlin.de volkhard.nordmeier@fu-berlin.de ruediger.tiemann@chemie.hu-berlin.de annette.upmeyer@biologie.hu-berlin.de dirk.krueger@fu-berlin.de
Homepage	http://www.kompetenzen-im-hochschulsektor.de/225_ENG_HTML.php
Time frame	01/11/2011 – 30/04/2015

References

- Abell, S. K. (2007). Research on science teacher knowledge. In Abell, S. K., & Lederman, N. G. (Eds.), *Handbook of research on science education* (pp. 1105–1150). New York: Routledge.
- American Association for the Advancement of Science. (1993). *Benchmarks for science literacy: Project 2061*. New York: Oxford University Press.
- Baumert, J., & Kunter, M. (2006). Stichwort: Professionelle Kompetenz von Lehrkräften [Keyword: Professional competencies of teachers]. *Zeitschrift für Erziehungswissenschaft*, 9(4), 469-520.
- Bybee, R. W. (2002). Scientific Literacy - Mythos oder Realität [Scientific literacy – myth or reality]. In Gräber, W., Nentwig, P., Koballa, T., & Evans, R. (Eds.): *Scientific Literacy. Der Beitrag der Naturwissenschaften zur Allgemeinen Bildung* [Scientific literacy. The contribution of science to general education] (pp. 21-43). Opladen: Leske + Budrich.
- Kunter, M. (2010). Modellierung von Lehrerkompetenz [Modelling competence of teachers]. *Zeitschrift für Pädagogik*, 56, 307-312.
- Mayer, J. (2007). Erkenntnisgewinnung als wissenschaftliches Problemlösen [Scientific inquiry as scientific problem solving]. In Krüger, D., & Vogt, H. (Eds.): *Theorien in der biologiedidaktischen Forschung* [Theories in research in biology education] (pp. 177–186). Berlin: Springer.
- National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academic Press.
- Reinhold, S. (2004). Naturwissenschaftsdidaktische Forschung in der Lehrerbildung [Research in science education in the field of teacher education]. *Zeitschrift für Didaktik der Naturwissenschaften*, 10, 117-145.
- Schecker, H., & Parchmann, I. (2006). Modellierung naturwissenschaftlicher Kompetenz [Modelling of scientific competence]. *Zeitschrift für Didaktik der Naturwissenschaften*, 12, 45-66.
- Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Teacher Education*, 88(4), 600-645.
- Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland (2010). *Ländergemeinsame inhaltliche Anforderungen für die Fachwissenschaften und Fachdidaktiken in der Lehrerbildung* [Common content requirements of content knowledge and pedagogical content knowledge in teacher education]. Berlin, Bonn: Kultusministerkonferenz. Retrieved from http://www.akkreditierungsrat.de/fileadmin/Seiteninhalte/KMK/Vorgaben/KMK_Lehrerbildung_inhaltliche_Anforderungen_aktuell.pdf
- Upmeyer zu Belzen, A., & Krüger, D. (2010). Modellkompetenz im Biologieunterricht [Model competence in biology teaching]. *Zeitschrift für Didaktik der Naturwissenschaften*, 16, 41–57.
- Von Aufschnaiter, C., & Blömeke, S. (2010). Professionelle Kompetenz von (angehenden) Lehrkräften erfassen – Desiderata [Assessing professional competencies of (pre-service) teachers – Desiderates]. *Zeitschrift für Didaktik der Naturwissenschaften*, 16, 361-367.
- Wissenschaftsrat (2008). *Empfehlungen zur Qualitätsverbesserung von Lehre und Studium* [recommendations for improvement in quality of teaching and studies] (No. Drs. 8639-08). Berlin: Wissenschaftsrat. Retrieved from http://www.wissenschaftsrat.de/download/archiv/86_39-08.pdf
- Zlatkin-Troitschanskaia, O., & Kuhn, C. (2010). Messung akademisch vermittelter Fertigkeiten und Kenntnisse von Studierenden bzw. Hochschulabsolventen: Analyse zum Forschungsstand [Measuring academic skills and knowledge of students and graduates: Analyzing the state of research]. *Arbeitspapiere Wirtschaftspädagogik, Nr. 56*. Mainz: Johannes Gutenberg-Universität.

Project Ko-WADIS

Evaluating the development of scientific inquiry competencies in academic science teacher education

Jurik Stiller, Sabrina Mathesius, Philipp Straube, Stefan Hartmann, Volkhard Nordmeier, Rüdiger Tiemann, Annette Upmeyer zu Belzen & Dirk Krüger

Educational Significance & Aims

Modelling and assessing competencies is currently promoted as the basis for policy control (e.g. Klieme, Leutner, & Kenk, 2010), particularly in the area of primary and secondary education. Most recently, a transfer of the term competency to the field of teacher education can be stated (Kunter, 2010). Von Aufschnaiter and Blömeke (2010) now demand a competence-oriented teacher education research in the natural sciences (see also Schecker & Parchmann, 2006; Reinhold, 2004). Of particular importance are the skills in terms of scientific inquiry, understood as a component of teachers' professional knowledge (see Baumert & Kunter, 2006). These have mainly been investigated in the field of primary and secondary education. However, in higher education, so far only a few studies exist (e.g. in physics Woitkowski, Riese, & Reinhold, 2011). For an evaluation of skills in scientific inquiry, there is a lack of adequate measurement instruments.

In this project, this desiderate is met through a large-scale assessment of science student teachers' competencies in the field of scientific inquiry.

Therefore, a paper-and-pencil-test with multiple-choice (single-select) items has been constructed, based upon theoretical models of Mayer (2007) and and Upmeyer zu Belzen and Krüger (2010; see figure 1).

Competence structure model

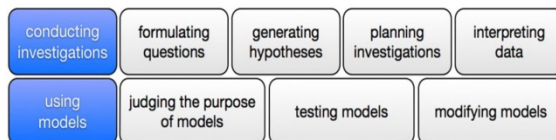


Figure 1. Domains (blue) and sub-dimensions (grey) of scientific inquiry.

Selected project publications

Hartmann, S., Krüger, D., & Upmeyer zu Belzen, A. (2012, September). *Ko-WADIS. Kompetenzmodellierung und -erfassung zum Wissenschaftsverständnis über naturwissenschaftliche Arbeits- und Denkweisen bei Studierenden (Lehramt) in den drei naturwissenschaftlichen Fächern Biologie, Chemie, Physik*. Poster presented at the annual meeting of Arbeitsgruppe für empirische pädagogische Forschung (AEPF), Bielefeld.

Mathesius, S., Upmeyer zu Belzen, A., & Krüger, D. (2013, March). *Kompetenzmodellierung naturwissenschaftlicher Erkenntnisgewinnung bei Lehramtsstudierenden (Ko-WADIS)* [Modeling student teachers' competencies in scientific inquiry]. Poster presented at the annual meeting of Internationale Frühjahrschule der Fachsektion Didaktik der Biologie im VBiO, Leipzig.

Stiller, J., & Tiemann, R. (2013). Scientific Inquiry im Studium — Längsschnitt zur Kompetenzerfassung im Lehramt Chemie [Scientific inquiry in higher education — longitudinal assessment of chemistry student teachers' competencies]. In S. Bernholt (Ed.), *Inquiry-based Learning - Forschendes Lernen. Gesellschaft für Didaktik der Chemie und Physik. Jahrestagung in Hannover 2012* (pp. 641–643). Kiel: IPN.

Straube, P., & Nordmeier, V. (2013). Längsschnitt zur SI-Kompetenzerfassung Physik[Lehramts]-Studierender. [Longitudinal survey to investigate the SI-competencies of physics student teachers]. In S. Bernholt (Ed.), *Inquiry-based Learning – Forschendes Lernen. Gesellschaft für Didaktik der Chemie und Physik. Jahrestagung in Hannover 2012* (pp. 539–541). Kiel: IPN.

References

- Baumert, J., & Kunter, M. (2006). Stichwort: Professionelle Kompetenz von Lehrkräften [Keyword: Professional competencies of teachers]. *Zeitschrift für Erziehungswissenschaft*, 9(4), 469–520.
- Klieme, E., Leutner, D., & Kenk, M. (2010). Kompetenzmodellierung [Modelling of competence]. *Zeitschrift für Pädagogik*, 56, 9–11.
- Kunter, M. (2010). Modellierung von Lehrerkompetenz [Modelling of competence of teachers]. *Zeitschrift für Pädagogik*, 56, 307–312.
- Mayer, J. (2007). Erkenntnisgewinnung als wissenschaftliches Problemlösen [Scientific inquiry as scientific problem solving]. In D. Krüger & H. Vogt (Eds.), *Theorien in der biomedizinischen Forschung* (pp. 177–186). Berlin, New York: Springer.
- Reinhold, S. (2004). Naturwissenschaftsdidaktische Forschung in der Lehrerbildung [Research in Science Education in the field of teacher education]. *Zeitschrift für Didaktik der Naturwissenschaften*, 10, 117–145.
- Schecker, H., & Parchmann, I. (2006). Modellierung naturwissenschaftlicher Kompetenz [Modelling of scientific competence]. *Zeitschrift für Didaktik der Naturwissenschaften*, 12, 45–66.
- Upmeyer zu Belzen, A., & Krüger, D. (2010). Modellkompetenz im Biologieunterricht [Model competence in biology teaching]. *Zeitschrift für Didaktik der Naturwissenschaften*, 16, 41–57.
- Von Aufschnaiter, C., & Blömeke, S. (2010). Professionelle Kompetenz von (angehenden) Lehrkräften erfassen – Desiderata [Assessing professional competencies of (pre-service) teachers – Desiderates]. *Zeitschrift für Didaktik der Naturwissenschaften*, 16, 361–367.
- Woitkowski, D., Riese, J., & Reinhold, P. (2011). Modellierung fachwissenschaftlicher Kompetenz angehender Physiklehrkräfte [Modelling of Competence in the Subject of Prospective Physics Teachers]. *Zeitschrift für Didaktik der Naturwissenschaften*, 17, 315–337.

Methodology

- longitudinal large-scale assessment of science student teachers' competencies in the field of scientific inquiry
- multiple-choice (single-select) items in paper-and-pencil-booklets
- $N \approx 3\,500$ student teachers (biology, chemistry and physics) in Berlin, Innsbruck and Vienna in different stages of their studies



- $N = 650$ student teachers (biology, chemistry and physics) of Humboldt-Universität zu Berlin and Freie Universität Berlin
- essay-items dealing with “conducting investigations” and “using models” in various fields of chemistry, biology and physics
- item-pool of 150 items was used to generate booklets
- data are analysed towards choosing of distractors and item parameters (e.g. discrimination, difficulty)
- findings will serve as basis for item selection

Research questions

- What empirical evidence can be found to support this theoretical predicted model of competencies?
- How does the competencies in the field of scientific inquiry develop during the phase of academic teacher training?

Outlook

By 2015, information about the structure and development of science students teachers' competencies in the field of scientific inquiry shall be elicited, and thereby tangible recommendations concerning the conception of university courses shall be derived.

Ko-WADIS is part of **KoKoHs**, in cooperation with the **IQI**:

